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Wide-Field Variability Surveys: A 21st Century Perspective

A search for low-metallicity pulsating B stars

Chris Engelbrecht[1,⋆], *Refilwe* Kgoadi[1,2], and *Fabio* Frescura[3]

[1] *Department of Physics, University of Johannesburg, PO Box 524, Auckland Park, Johannesburg 2006, South Africa*
[2] *College of Science and Engineering, James Cook University, Douglas, Townsville 4810, Queensland, Australia*
[3] *School of Physics, University of the Witwatersrand, Private Bag 3, WITS, Johannesburg 2050, South Africa*

Abstract. We report on some recent results from a long-term $UBVI$ survey of various fields in the Large Magellanic Cloud (LMC), which is aimed at identifying and classifying pulsating B stars in the selected LMC fields. Difference Imaging Analysis shows a clear advantage over conventional PSF fitting. Tentative indications have been found of a varying incidence of pulsation amplitudes (and, by inference, of metal content of the pulsators) across the LMC bar.

1 Introduction

Until about a decade ago, models of main-sequence B stars set a lower threshold of $Z = 0.01$ on the metallicity required to enable β Cephei-type pulsation through the kappa mechanism (e.g., [9]). (Slightly lower metallicity thresholds were found for excitation of SPB-type pulsation.) The subsequent firm discovery of three β Cephei (BCep) stars in the Large Magellanic Cloud (LMC, [10]) using OGLE data, and the reporting of 92 BCep candidates in the LMC (and 6 BCep candidates in the Small Magellanic Cloud, SMC) by [6], further bolstered by the results of [4] and [5], prompted more detailed work on models of main-sequence B stars, as well as the exploration of the conditions required for pulsation instability in these stars. As the BCep pulsations are driven by the iron-group (Fe/Ni/Mn/Cr) opacity bump at 160 000 K (through the kappa mechanism), plausible reasons for increasing either the abundances of these elements, or the opacities due to them (or both), were explored. Some workers ([7] and [11]) were able to lower the threshold for pulsation excitation to $Z = 0.007$ by using new opacity calculations. Subsequently, [12] showed model calculations which generated BCep pulsations at both LMC and SMC metallicities (i.e., down to $Z = 0.004$) through an ad hoc amplification of, specifically, the Ni opacity at the bump. Recently, [8] followed up on the report by [2] on direct laboratory measurements of iron opacity in stellar conditions, showing a 75% enhancement of iron opacity, to re-calculate the BCep and SPB instability strips. A modest expansion of these strips was found.

Despite these efforts, the claimed detections of BCep and SPB stars in the LMC and SMC remain inexplicable without invoking ad hoc measures. Since this conundrum might be resolved by ascertaining the actual pulsational properties and physical parameters of both confirmed and suspected BCep

⋆engelbrecht.chris@gmail.com

stars in the LMC and SMC, a ground-based observing campaign was constructed to do exactly this. The LMC was selected as the target for this campaign as it would be far more likely to produce a positive result within the project's design constraints than the SMC.

2 Project details and results

Five distinct 2.6 arcmin × 2.6 arcmin fields in the LMC were observed in Johnson $UBVI$, producing about 600 useful time series points per filter, per field. The fields were selected based on a Fourier transform run through OGLE data, looking for power in the BCep frequency domain. We will apply for time on the new High-Resolution Spectrograph (HRS) on SALT to obtain spectra of all pulsators found in our sample of the LMC, with the express purpose of determining elemental abundances. We initially used PSF fitting in IRAF to identify potential B stars. Standard calibrations of Johnson photometric indices were then used to estimate key physical parameters of those stars. Lomb-Scargle periodograms and associated statistical significance estimates were calculated for those stars that occupy the expected instability strip, based on calibrations of the photometry. In general, the IRAF-based photometry data produced many marginal/dubious cases of pulsation detection. A greater deal of success is now being achieved with the pyDIA code ([1], [3]). Preliminary analysis of the time series obtained suggests that pulsations appear more frequently – and also with higher amplitudes – as one moves to the eastern side of the bar of the LMC. Final results of pulsation frequencies, amplitudes and modal types will be presented once this analysis is complete.

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